THE IRON ORES AND LIGNITE

—OF THE—

MONTGOMERY COUNTY VALLEY.

—BY—

HENRY CARVILL LEWIS,

Of the Second Geological Survey of Pennsylvania.

[*Read before the Mineralogical and Geological Section of the Academy of Natural Sciences of Philadelphia, October 27th*, 1879.]

THE IRON ORES AND LIGNITE

—OF THE—

MONTGOMERY COUNTY VALLEY.

—BY—

HENRY CARVILL LEWIS,

Of the Second Geological Survey of Pennsylvania.

[*Read before the Mineralogical and Geological Section of the Academy of Natural Sciences of Philadelphia, October 27th*, 1879.]

[*Reprinted from the Proceedings of the Mineralogical and Geological Section of the Academy of Naturol Sciences of Philodelphia, October* 27, 1879.]

THE IRON ORES AND LIGNITE OF THE MONTGOMERY CO. VALLEY

BY HENRY CARVILL LEWIS.

The discovery of lignite in the iron ore region north of Philadelphia introduces some new considerations in the study of its geology, and has a direct bearing upon the age of its iron ores. Lignite was found in this valley many years ago, but was supposed to be Triassic, and therefore unimportant.[1] Before judging of the connection that the occurrence of lignite in the Montgomery Co. limestone valley will have with the geology of the Atlantic coast, it will be important to enumerate other localities of a similar nature where that mineral has been found.

In his Geology of Vermont, Prof. E. Hitchcock described an occurrence of lignite in a similar position at Brandon, Vt., and proposed a theory which excited much attention, but which has been rejected by many geologists. It was shown that a steeply-dipping stratum of lignite lay within beds of plastic clay, kaolin and iron ore, all dipping steeply southeast. The iron ore deposit was sometimes 100 feet deep, and all these beds rested against a limestone which had the same steep dip. Mottled clays were described as similar to those of Martha's Vineyard and the Isle of Wight, and much of the formation was said to resemble a metamorphosed mica schist. The stratum of lignite was opened from near the surface to a depth of 80 feet, and was used as coal. It proved to be generally dicotyledonous, and to contain twigs and fruits which belonged to a tropical climate, and which Professor Lesquereux referred to a Tertiary epoch, probably Miocene. From this discovery, Prof. Hitchcock proposed the theory that all the limonite iron ores of the Atlantic coast in similar geological positions were Tertiary and of oceanic origin. On the other hand, it was argued that an isolated example was not sufficient to establish such a wide conclusion, and the lignite was regarded as locally formed by having been washed into an existing cavern in the limestone floor.

The next occurrence of lignite is a very similar one at Pond Bank, near Chambersburg, Pa., described in an interesting

[1] *V.* Prof. Leidy, Proc. Acad. Nat. Sci., Phila., 1861, 77.

paper by Prof. Lesley.[1] Here again it was found in a limestone valley close to iron ore excavations. It was at a depth of 40 feet, below strata of clay and sand. According to the superintendent of the mine, it was in two strata, the lowest of which was 18 feet in thickness, and was separated from the upper bed, 4 feet thick, by a stratum of sand. Below it, at a depth of 65 feet, red and white plastic clay occurred. The strata were nearly horizontal. It was thought that the lignite was not neeessarily connected with the iron ores, but was a local deposit of late date, made in a shallow pond, and that, as at Brandon, a sink-hole had been formed in the underlying limestone. It was regarded as of the latest Tertiary age.

Lignite has also recently been discovered by Prof. Prime, in Brown's iron mine, at Ironton, Lehigh Co., Pa.[2] He states that it occurs in a white plastic clay, but does not give the depth at which it was found. He believes that it was transported by ice and water in the Glacial epoch, and refers the iron ores of the valley to the same origin.

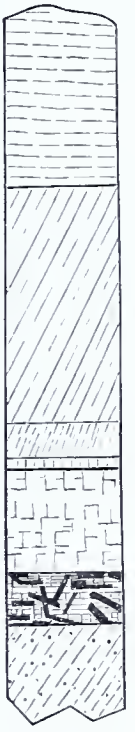
The writer believes that in the light of facts now developed, this theory of the age of the lignite cannot be maintained. After an inspection of the locality, he has found that the surface-drift and boulders of that valley lie unconformably upon the formation eontaining the lignite. The lignite lies at a depth of 46 feet from the surface, in a tough plastie elay, which is entirely free from boulders. About 30 feet of potters' clay and decomposed hydromica slate lie upon the lignitic stratum, and resting upon the whole is 15 feet of drift. This surfaee drift, of yellow brick-clay, boulders, gravel and drift iron ore, is thus of quite different characeter from the strata below it, and is probably deposited by glacial waters. The underlying formations have, apparently, in some plaees, a dip like that of the adjacent limestone, and are eertainly more aneient than the surfaee drift.

The lignite reeently found by the writer in the Montgomery Co. valley, and deseribed at the last meeting of the Seetion, occurs under conditions very similar to those above indicated. In immediate proximity both to a limestone outcrop and to iron ore diggings, it was found at a depth of 35 feet, in a plastic clay which eontains no gravel or boulders, and which is overlaid by

[1] Proc. Amer. Phil. Soc., ix, 463.

[2] Report DD., 2d Geolog. Survey of Pa., p. 76.

clay and decomposed hydromica slate. A surface drift, containing iron ore, gravel, and occasional boulders, lies unconformably upon the whole formation. The section here presented was made in a shaft which the writer was allowed to have sunk within a few feet of Mr. Hitner's marble quarry, Marble Hall, Montgomery County.



FEET.	
10	"Top dirt," yellow, impure.
13½	Soft white decomposed hydromica slate or impure "kaolin." containing occasional broken seams of sharp quartzite, but no pebbles.
2	Coarse white sand and rounded pebbles; apparently a decomposed sandstone.
½	Tough mottled red clay.
7	Blue plastic clay.
3	*Lignite* in a very tough. dark clay.
2+	Coarse yellow sand, with fragments of stony iron ore and with pebbles.

The lignite bed contains occasional streaks of fine gray sand, and is underlaid by a coarser sand. So far as could be judged from the very limited exposure, it dipped south, at an angle of about 30°; becoming thicker as it dipped. The lignite lies in fragments in the clay, and consists of twigs and branches of land plants, apparently all dicotyledonous. The lignite frequently shows a brilliant black lustre when transversely fractured. The small fragments are more like charcoal, and are often in the form of flattened twigs. Some of these appear to be partially rounded by attrition. No shells or marine fossils occur. Pyrite frequently encrusts the lignite or forms nodules, and when exposed to the air decomposes into ferrous sulphate.

At this same locality, lignite has been taken from three other shafts in addition to the one just described. Two of these are

close to the Marble Quarry, but the third is about 400 feet east of these, behind the barn of Mr. H. S. Hitner, who says that it was found many feet below the surface. These facts indicate an east and west strike to the lignitic strata, and an extent of 400 feet in length and 40 feet in breadth. Shafts 100 feet north of these struck iron ore, but no lignite. They exhibited the following succession of strata:—(1) "Top dirt;" (2) Decomposed hydromica slate; (3) White clay; (4) Yellow sand; (5) Iron ore.

Recent explorations have shown that Marble Hall is not the only locality where lignite is found, but that it occurs in a number of other places in the same valley. About a mile and three-quarters west of Marble Hall it was formerly found in a field on the Ridge Road, opposite a house once owned by W. Potts. It was at a depth of about 40 feet. Red and white potters' clay, white kaolin and iron ore are found close to the opening. The lignite at this place is hard, and is said to burn well. Another locality is on the farm of W. Wills, south of Plymouth Creek, about one mile from Conshohocken. Considerable quantities of lignite have been here exhumed, the pieces being often a foot in length. This shaft was opened about thirty years ago, and was probably the locality referred to by Dr. Leidy. Lignite has also been found in a number of iron ore pits south of here and east of Conshohocken. It is said always to occur in fire-clay.

The above localities are all included in a strip of country about two and a-half miles long and a quarter of a mile broad, lying in nearly an east and west direction. The lignite appears to form two distinct, narrow lines of outcrop with a definite E. and W. or E. N. E. and W. S. W. strike,—thus conforming with the limestone. While its dip has not been actually established, the decomposed slates and sandstones of apparently similar age have been observed to dip 40° S. 20° W.

From these facts it would appear that the lignite is not a mere local wash or accidental deposit, but that it is part of a stratified and distinct formation, having a trend like that of the limestone, and of considerable extent; and when the strata in the Montgomery County Valley are compared with those in other parts of the country, it will be seen that we have here to deal with a formation which, closely connected with the limonite iron ores of the great limestone valleys, and having remarkably similar characters throughout, may prove an important feature in American geology.

In entering upon a consideration of the *age* of the lignite, it will

be desirable briefly to sketch the geology, and especially the surface geology of the valley in which it occurs.

The underlying rock is an altered lower Silurian limestone, the "Auroral" of Rogers, which in the southern part of the valley is crystalline marble and in the northern part is a sandy magnesian limestone. It has an E. and W. strike and a steep south dip, and is supposed to have an inverted synclinal structure. The limestone rises to the surface in a series of parallel ridges, and between these lie the iron ores and the lignitic strata. Bounding the valley are hills of altered shale of probably Potsdam age. Beyond this line of hills to the north, are the Triassic red shales and sandstones, while to the south is the Philadelphia gneissic district. In many places the North Valley Hill has been eroded away and Triassic strata lie directly upon the limestone.

The iron ores of this region probably belong to four different geological ages, and may therefore be divided into four classes.

1. Gneissic Ore. This ore, never found in the valley, occurs in the gneissic rocks of Chester County north of the Chester Valley, and has been formed in place from the altered gneiss. It dips with the gneiss, and is generally accompanied by scales of graphite. Prof. Rogers[1] supposed that this ore belonged to isolated patches of Triassic red sandstone. The writer, however, has not been able to confirm his sections, nor to show the presence of any more recent formation than the gneiss.

2. Primal Ore. The hydromica slates which lie between the Potsdam sandstone and the limestone liberate, when decomposed, a rich limonite ore which is largely mined in portions of the valley. Although in very irregular beds, a steep dip can be recognized. It is perhaps derived from the decomposition of pyrite. This is probably the ore mined at Edge Hill.

3. Tertiary Ore. This ore, associated with which are the deposits of lignite, plastic clay, kaolin, fire-sand, etc., has been hitherto confounded either with the Primal ore or with the Drift ore of the valley. In that part of the valley under discussion there are three distinct lines of outcrop of this ore, having nearly an E. and W. trend. A ridge of limestone separates two of these lines. The ore lies, sometimes at a great depth, below a re-stratified decomposed hydromica slate. This latter formation is almost identical in appearance with the decomposed Primal slate in place

[1] Geol. of Penna., I, 87.

at the edges of the valley, and has therefore been mistaken for it. The discovery of lignite below it proves its re-stratification in a later age. In many places shafts have been sunk over 100 feet without coming to the limestone. The ore, originally derived either from the limestone or from the primal slates, appears to lie below the lignitic strata.

4. Drift Ore. Resting often unconformably upon these last, and capping the elevations throughout the valley, is a drift deposit of gravel and boulders containing a workable iron ore. The composition of this drift is most interesting. Its boulders, almost without exception, are composed of a loose-grained Potsdam sandstone,—a formation not now existing either on the North or South Valley Hill at this place, and found only in a limited exposure at the eastern end of the valley. The *Scolithus linearis* is frequently found in these boulders. Moreover, notwithstanding the large extent of Triassic red shale and sandstone immediately to the north of the valley, and the occurrence of that rock resting often directly upon the limestone, not a trace nor a fragment of Triassic rocks have been found in this drift.

The evidence is here strong that this drift has not been caused by any flood from the north in a modern age. Additional evidence bearing upon the same point is found in the fact that the Triassic region north of here is absolutely free from drift of any kind. A careful study by the writer of much of that region has shown that not a single drifted pebble is there found. The soil is formed from the rocks below it, and such clays as occur are bog clays of local origin and recent age. That the pebbles of the valley drift have not been derived by weathering from the neighboring lower Triassic conglomerate, which holds often large pebbles, is shown by the fact that such pebbles are here formed entirely of gneiss or gneissic quartzite, and never of Potsdam, and therefore are quite different from those in the valley.

The drift ore and gravel does not lie in hollows, as though locally washed, but is found in patches upon the elevated portions of the valley, as though it were the remnant of a once continuous deposit.

The facts above enumerated suggest a possible origin at an age when cliffs of Potsdam sandstone, since eroded away, stood as a high barrier between the limestone valley and the Triassic rocks north of it. Such a barrier would effectually prevent Triassic fragments from mixing with the drift of the valley, and would,

during its degradation, offer the material for the pebbles and boulders of that drift. In Triassic times some such barrier may have formed the southern shore of the Triassic waters. It has been interesting to discover that most of the pebbles belonging to the sub-Cretaceous plastic clays of the Delaware are formed of Potsdam sandstone, and that therefore during lower Cretaceous times also, some such mountain of Potsdam must have offered itself to eroding agencies. Again, it is found that Tertiary gravels, both in Pennsylvania and New Jersey, contain an abundance of Potsdam pebbles. The hypothesis that the materials for the sub-Cretaceous plastic clays and the Tertiary gravels were furnished by hills now sunk beneath the Atlantic Ocean [1] is not sustained by what is known of the configuration of the sea-bottom. The theory now offered is supported by numerous facts concerning the power of erosion, which geological considerations in other fields have presented.

In a former paper on "The Surface Geology of Philadelphia and vicinity," the writer showed that, in addition to the clays, four separate gravels of different ages can be distinguished in that region. These are (1) "The River Gravel," the newest of all the gravels; (2) "The Philadelphia Red Gravel," of Champlain age; (3) "The Fossiliferous Gravel," recently proved by the writer to be of upper Tertiary, perhaps Pliocene age, and now called the "Glassboro Gravel;" (4) "The Bryn Mawr Gravel," the oldest of the gravels, also oceanic, and conjectured to be of upper Miocene age. This last gravel, and this only, agrees in its characters with the valley drift now under consideration. In the absence of all Triassic fragments, in the presence of Potsdam boulders, and in the amount of erosion, these two gravels are identical, and it seems probable that the "Drift Iron Ore" of the one is only a very ferruginous variety of the "Mt. Holly Conglomerate" of the other. This being the case, we have here a formation which, notwithstanding its boulders, suggestive of floating ice, appears to be older than an oceanic Pliocene gravel. There is perhaps no good reason why a glacier might not have existed in upper Tertiary times, boulders formed by which may still be found. However this may be, it appears that there are strong grounds for assigning an upper Tertiary age to the drift ore and gravel of the Montgomery County Valley.

Returning, finally, to the lignite and associated strata, shown to

[1] Report on Clay Deposits of N. J., 1878, pp. 20.31.

be older than the formation just described, and shown by its own characters to bear no trace of glacial agencies, we may conjecture, without any reference to the plants of the lignite, a middle or lower Tertiary age. From the steep dip of the beds,—a fact difficult to explain,—and from the great resemblance of the plastic clays to those in New Jersey, on the Delaware, the writer at first supposed them to be of Wealden age. Some facts in connection with a gravel found in Virginia and other Southern States, which, in both appearance and position is very similar to the Bryn Mawr gravel, were at first thought to indicate a Jurassic age. But after a comparison with the other lignite localities, and especially with that at Brandon, where the fossils were shown to be of Tertiary age, this view can hardly be sustained. The absence of shells or marine plants indicates a period of inland waters, and the plants at Brandon belong to a tropical climate.

It is now suggested that the period of the lignite may correspond most closely with that called by European geologists the Oligocene. Since, in the present state of our knowledge, it is obviously unsafe to make the age of these lignite deposits contemporaneous with any exact geological epoch, and as there is a possibility of their belonging to some period not recognized elsewhere, it will probably be wiser for the present to group them together under the name of *The Brandon Period*. As more facts develop and wider comparisons can be made, more certain conclusions will be possible; and it must be understood that the theories here proposed are brought forward only as those which now appear best to explain the facts observed.

Postscript.—Since the presentation of the above paper, the writer has been in correspondence with Prof. N. A. Bibikov, of Augusta, Georgia, who has recently discovered lignite in that vicinity. The locality, called "Read's Brown Coal Mine," is in Richmond County, two and a-half miles from Berzelia, and sixteen miles from Augusta. It is described as lying back of the outcrops of gneiss and limestone, and is apparently in a very similar geological position to the Pennsylvania locality. Iron ore, plastic clay, kaolin, and decomposed sandstone occur with the lignite. As in Pennsylvania, the lignite was found in a plastic clay beneath 25 feet of a decomposed sandstone. Four strata of lignite, separated by layers of shale and clay, were found at a depth of from 30 to 45 feet from the surface. A series of coarse and fine sands and clays underlaid these deposits and were penetrated to a depth of 95 feet

Three different shafts were sunk, the extremes being 600 feet apart, in all of which lignite was found. The shaft in which the following section was made is about 150 feet from an outcrop of hornstone and quartzite, and 300 feet from a creek which lies 200 feet below it.

4	Mottled clay.
	Decomposed sandstone.
	Crust of iron sandstone and spathic iron.
24	Decomposed sandstone with thin layers of clay.
	Nodules of pyrite.
2	Lignite.
1	Shale and clay.
3	Lignite.
2	Shale and clay.
1	Lignite.
3	Shale and clay.
5	Lignite.
6	Light-colored shale with fossil plants.
1	Dark-colored (bituminous) shale.
8	White clay with streaks of rose-color, etc.
1	Sandy clay.
9	Ferruginous coarse sand with nodules of clay iron-stone, 4 inches to 2½ feet in diameter, with ochre, clay, etc., and quartz pebbles sometimes 3 inches in diameter.
4	Light-colored shale.
2	Yellowish sand.
8	Sandy clay.
11 +	White, very fine micaceous sand with clay.

The second stratum of lignite is the best, and contains fragments of lignite sometimes three feet long. A number of fossil plants have been found in this and other layers. Some specimens were imbedded in a layer of brown sandstone. The fossils appear to be fragments of trees, grasses and other land plants, none of which, however, were sufficiently perfect to be determined. No shells were found.

The whole section at Berzelia is remarkably similar to those at Brandon, Chambersburg, Ironton and Marble Hall, and with them indicates the existence of a great inland fresh water Tertiary formation in Eastern America, during the Brandon Period, once fifty miles broad and nearly a thousand miles long.